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# Blue Belt

# Water Quality Expedition

# Survey Report

**Diego Garcia March/April 2019**

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Blue Belt Programme

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## 1. Introduction

The UK's Overseas Territories are home to over 90% of the UK's biodiversity and are of fundamental importance to regional and international marine conservation. The Blue Belt Programme supports the delivery of the UK Government's commitment to enhance marine protection of over four million square kilometres of marine environment across UK Overseas Territories.

The British Indian Ocean Territory (BIOT; also known as the Chagos Archipelago) consists of five low lying coral atolls (58 islands in total) surrounded by a 640,000 km<sup>2</sup> maritime zone which was declared a 'no-take' marine protected area (MPA) in 2010 (Figure 1). The archipelago lies around 500 km south of the Maldives. BIOT consists of around 6,000 km<sup>2</sup> of shallow reef zones with the remainder of bathyal and abyssal depth (>2,000 m). The majority of BIOT waters are tropical and oligotrophic. The largest atoll, Diego Garcia, is located to the south east of the archipelago (Figure 1). Diego Garcia hosts a joint US-UK defence facility which includes an operational airport and a deep-water basin to accommodate large vessels.

In March/April 2019 Cefas undertook a survey to collect information and samples for water quality assessment at Diego Garcia, working within the lagoon and in marine (coastal) waters outside the lagoon. The survey team departed the UK on the 19<sup>th</sup> March and arrived in BIOT on the 21<sup>st</sup> March. The team departed Diego Garcia on the 2<sup>nd</sup> April and returned to the UK on 4<sup>th</sup> April. The expedition team was made up of two Cefas scientists; Andy Smith and Paul Nelson.

## 2. Acknowledgements

Cefas would like to thank the BIOT Administration for their assistance and advice during the build up to the survey and during the fieldwork. In the field the Cefas team was assisted by Harri Morrall (Environment Officer for the BIOT Administration) who provided invaluable knowledge of DG and was a very willing assistant during sample collection. Blue Belt would also like to thank the members of the UK Armed Forces stationed in BIOT and the facilities management of DG for their assistance in making this survey a success.

### 3. Aims and Objectives

The aim of the expedition was to carry out a baseline study on marine water quality at Diego Garcia (DG), to determine potential impacts on marine water quality due to:

1. Potential leaching from an unlined waste disposal pit into the lagoon.
2. Discharges from two sewage outfalls into marine waters.
3. Discharges or contamination from vessels at anchorage in the lagoon.

To inform these objectives a number of different sample types were collected across the survey area utilising different equipment and techniques. Samples were collected to inform the concentrations and levels of:

- Dissolved inorganic nutrients (nitrate, nitrite, ammonium, silicate, phosphate) in sea water
- Contaminants
- Heavy metals
- Dissolved Oxygen
- Microbiological pathogens (E. coli colony forming units)
- Whole sample toxicity

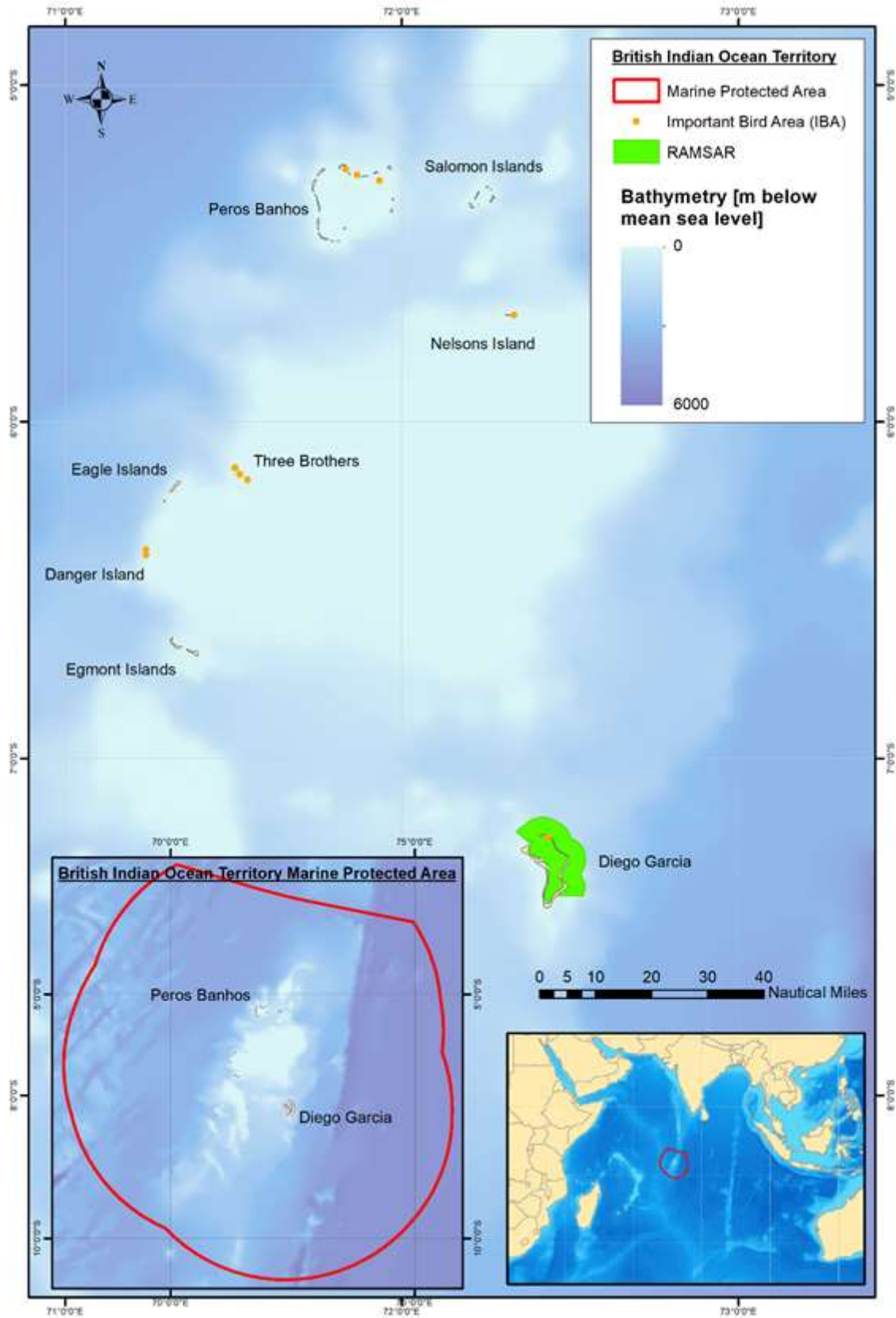


Figure 1. The British Indian Ocean Territory location and Marine Protected Area (MPA, indicated by red line).

## 4. Proposed Sampling Sites

Sampling sites were located to meet the three main objectives (Figure 2). The first set of sample locations was within the lagoon, adjacent to the unlined waste pit on the south-west side of DG. The second set of samples was collected adjacent to the wastewater (sewage) outfalls on the north and west coast. The third set of samples was collected in the central waters of the lagoon and outside the entrance to the lagoon, in locations previously sampled for the monitoring of the water quality around DG.

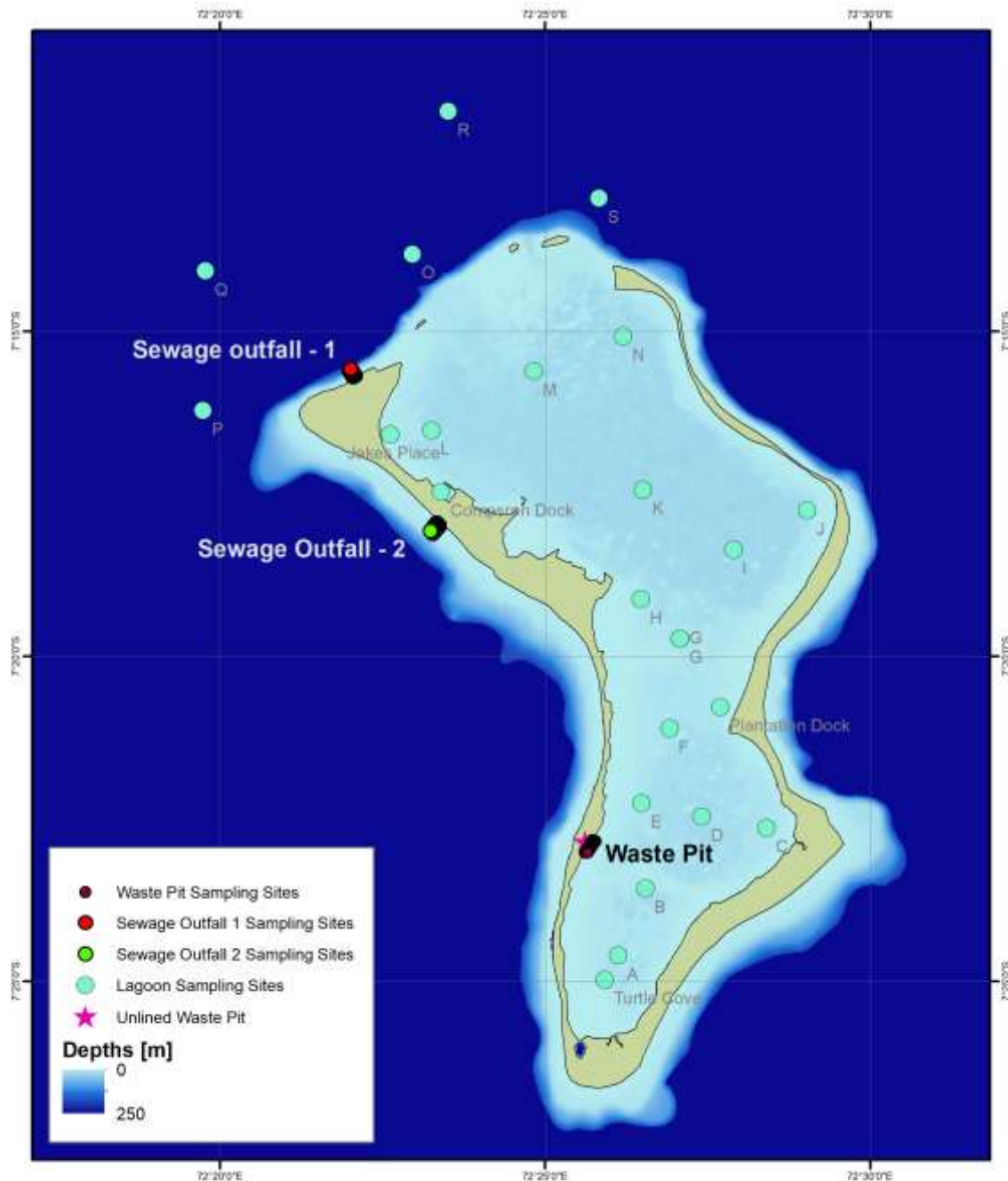


Figure 2. Proposed sampling sites at Diego Garcia: adjacent to the waste pit, at sewage outfalls, and in the central lagoon and outer areas (sites A to Q).

## 5. Sampling

Coastal water samples inside and outside the lagoon were collected either directly from the beach or, in deeper locations, samples were collected from a small vessel using a Niskin bottle. All samples were returned to the on-island Cefas lab for analysis or preservation depending on protocol.

The total number of samples collected, and the sample types, are detailed in Table 1. The locations where samples were collected are shown in Figure 3 and detailed in Annex I.

*Table 1: Sample types and number of samples collected from Diego Garcia.*

<b>Sample Type</b>	<b>Total Sample Numbers</b>
Passive Samplers for metals	12
Nutrient Samples	34
CTD Deployments	23
Microbiology (E.Coli)	34
Contaminants	22
Toxicity	41

Discrete water samples were collected for the analysis of nutrients, microbiology, contaminants and toxicity. Passive samplers, to detect trace and heavy metals, were placed in five locations within the lagoon (Figure 3). Environmental concentrations can be calculated following analysis of the samplers. The samplers were left in position for three days before being recovered and returned to the UK for analysis.

Profiles of water column characteristics were collected using a RBR Maestro CTD instrument. The sensors on the CTD are designed to measure:

- temperature
- salinity
- pH
- fluorescence
- turbidity
- dissolved oxygen

These metrics will be used to characterise the environmental conditions where discrete water samples were collected.



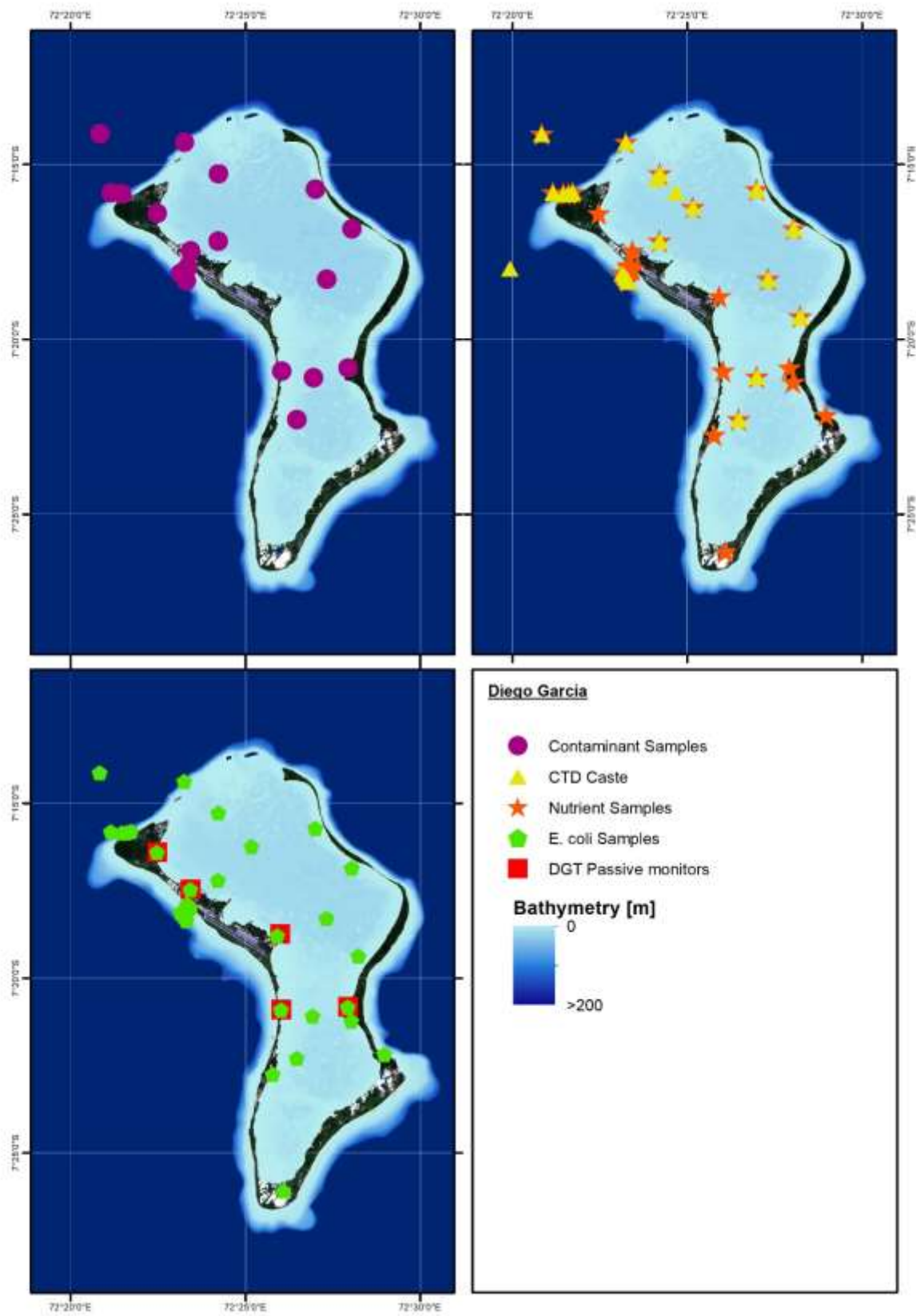


Figure 3: Sample locations during the Blue Belt Water Quality Survey in Diego Garcia 2019.

## 6. Survey Narrative

### **Tuesday 19<sup>th</sup>**

Team and equipment were transported to Heathrow and booked in the numerous large kit containers. The team arrived in Bahrain at 10.30 AST. There were long delays at customs due to some of the electronic equipment. Some of the equipment was held by customs for the duration of the stay in Bahrain and put into storage until we left the country.

### **Wednesday 20<sup>th</sup>**

Equipment which required chilling was dropped off at the Bahrain Supreme Council for the Environment (SCE).

### **Thursday 21<sup>st</sup>**

The team collected the chilled kit from SCE and transported it along with the other equipment to the airport. Delays were encountered on retrieving kit from customs, which was at the commercial airport, and getting it round to the airbase so it can be loaded onto the plane.

### **Friday 22<sup>nd</sup>**

The team arrived in BIOT at approximately 03:00 IOT and were met by the BIOT representative who helped us to sort the kit into his pick-up and then dropped the staff at their rooms. It became apparent that Andy had become quite unwell by this point. Paul and Andy met up with Harri (BIOTA) and collected the hire vehicle for the duration of the visit.

Harri introduced the team to some of the key people in the Territory: The British Representative (Brit Rep); the Executive Officer (XO); the Sergeant Major and the Environment and Facilities Manager for US Navy.

The team, along with Harri, went to the Leisure Marina to review the situation and the boats. The staff running the marina agreed to organise the boats to be around the following morning for review.

### **Saturday 23<sup>rd</sup>**

The boats all appeared to be well maintained and in good order in terms of hull, engines etc. Our main findings were that there are no life-rafts and no in-date flare packs which needed addressing before vessel-based work could commence. Otherwise good controls and procedures were in place including regular radio checks, engine checks, general condition checks and an engineer report every day. There is a US Navy Search and Rescue (SAR) unit just along the lagoon coast from the Marina. Risk mitigation to compensate for the lack

of life-rafts and flares, in terms of nearness of other boats and SAR team in case of incident, seems good.

### **Sunday 24<sup>th</sup>**

The lab space for sample preparation and analysis was set up in the agreed space and calibrations were performed on the CTD.

### **Monday 25<sup>th</sup>**

Paul and Harri performed a reconnaissance of the passive sampler positions at Moody Brooks, Waste Management and Thunder Cove.

### **Tuesday 26<sup>th</sup>**

A risk-based decision was made that Andy was still not fit enough after illness to do fieldwork. Harri and Paul drove around the island to place passive samplers and collect some shore-based samples. Samples for nutrients, microbiology, toxicity and contaminants were taken and passive samplers placed at old Plantation site and Moody Brook. Passive samplers were also placed at Thunder Cove.

### **Wednesday 27<sup>th</sup>**

Harri and Paul undertook a second land-based sampling day visiting more sites and ensuring Paul had a good grasp of the island geography before Harri returned to the UK the following day. Samples for nutrients, microbiology, toxicity and contaminants were taken and passive samplers placed at the waste management site and leisure marina site.

### **Thursday 28<sup>th</sup>**

Five sites were visited over the day. These were sites O, M, K, I and F. Water column profiles of conductivity (salinity), temperature and depth were measured using a CTD profiler. Samples were collected for nutrient, microbiological, contaminant and toxicity analysis. Nutrient and contaminant samples were preserved and stored as appropriate. Microbiology and toxicity analysis was carried out over the next few hours. Microbiology was carried out using a Wagtech Potatest II portable lab and Chromacult media for *E. coli* identification. Toxicity was assessed using the portable Deltatox FX microtox test kit, 15-minute incubation times for the samples and the low-toxicity sample method.

### **Friday 29<sup>th</sup>**

Paul was supported by a member of the Royal Marines and worked outside of the Lagoon, using the Royal Marines rib (and crew) as support vessel. A total of 11 sites were visited particularly focussing around areas expected to be impacted by sewage outfalls; sites E, P and Q, and Outfall locations S2a, S2b, S2c, S2d, S2e, S1a, S1b and S1c. CTD profiles,

nutrients, toxicology and microbiology samples were taken at all sites. One-litre contaminant samples were collected at sites E, S2a, S2e, S1a, P and Q only.

After the boat returned and all samples were processed, a second set of passive samplers for metal contamination were placed at the Leisure Marina to back up the other sets already in place.



*Figure 4: Deployment of the CTD (left) and filtering a water sample for nutrient analysis (right).*

### **Saturday 30<sup>th</sup>**

Another boat-work day, with a return to the lagoon. Paul and one of the Royal Marines visited 7 sites; Ma, Ka, Ia, J, H, G and Fa. CTD profiles were taken at all sites.

Sites Ia, J, H and Fa were sampled for nutrients, microbiology and toxicology. Contaminant samples were taken at sites J and H.

### **Sunday 31<sup>st</sup>**

Andy's first day in the field. A total of 10 sites was visited by land: Plantation old dock, Beach East Ocean (outside lagoon), Turtle Cove, Outfall S2f, S2g, S2h, S2i, S2j, Munition storage, Thunder Cove bay. Toxicology, microbiology and nutrient samples were collected at every site. Contaminant samples were collected at outfall sites S2f and S2g. No CTD deployments were made. The passive samplers at the old Plantation site were recovered and refrigerated.

### **Monday 1<sup>st</sup> April**

The team went to Moody Brook to collect the metals passive samplers there. Also collected the metals samplers from the leisure marina. Drove to the waste management site, collected the passive samplers previously deployed there. We also sampled a short transect along the beach centred around the metals dumping site for toxicity. The final action was to visit

the landfill leachate pond and take a sample to assess for toxicity. Six samples were collected in total for toxicity.

On returning to the on-island lab, toxicity assessment was carried out on the day's samples. All the remaining *E.coli* samples undergoing incubation from the 31<sup>st</sup> March were read. Packed up most of the lab, cleaned the surfaces, fridge, etc.

### **Tuesday 2nd April**

Demobilisation day. The last kit and personal belongings were packed. The team visited the Brit Rep and XO to drop off some gifts. The team flew back to the UK via Bahrain.



*Figure 5. Paul preparing the passive samplers before deployment.*

## Annex I – Sample Locations

Table A1.1. Locations where Passive Samplers (for analysis of metals) were deployed.

Sample No	Location	Depth (m)	Latitude	Longitude	Date in	Date Out	No. of samplers
1	Plantation R&R	1	-7.3472	72.4655	26/03/2019	31/03/2019	2
2	Thunder Cove	1	-7.3126	72.4332	26/03/2019	Failed	1
3	Moody Brook	1	-7.2735	72.3745	26/03/2019	01/04/2019	2
4	Waste Management	1	-7.3486	72.4338	27/03/2019	01/04/2019	3
5	Leisure Marina A	1	-7.2913	72.3905	27/03/2019	01/04/2019	1
6	Leisure Marina B	1	-7.2913	72.3905	29/03/2019	01/04/2019	4

Table A1.2. Locations where nutrient samples were collected from surface waters.

Sample No	Location	Depth (m)	Latitude	Longitude	Date	Time
1	Plantation R&R	0.5	-7.3472	72.4655	26/03/2019	15:30
2	Moody Brook	0.5	-7.2735	72.3745	26/03/2019	18:33
3	Waste Management	0.5	-7.3486	72.4338	27/03/2019	12:45
4	Leisure Marina A	0.5	-7.2913	72.3905	27/03/2019	17:27
5	Site O	1	-7.2396	72.3875	28/03/2019	08:30
6	Site M	1	-7.2546	72.4038	28/03/2019	09:00
7	Site K	1	-7.2868	72.4036	28/03/2019	09:30
8	Site I	1	-7.3049	72.4554	28/03/2019	10:00
9	Site F	1	-7.3518	72.4486	28/03/2019	10:21
10	Site E	1	-7.3718	72.4412	29/03/2019	10:44
11	Outfall S2a	1	-7.3056	72.3885	29/03/2019	08:35
12	Outfall S2b	1	-7.3060	72.3884	29/03/2019	08:50
13	Outfall S2c	1	-7.3046	72.3880	29/03/2019	09:00
14	Outfall S2d	1	-7.3037	72.3870	29/03/2019	09:16
15	Outfall S2e	1	-7.3021	72.3856	29/03/2019	09:40
16	Outfall S1a	1	-7.2642	72.3577	29/03/2019	10:10
17	Outfall S1b	1	-7.2634	72.3621	29/03/2019	10:21
18	Outfall S1c	1	-7.2641	72.3601	29/03/2019	10:34
19	Site P	1	-7.2636	72.3526	29/03/2019	10:50
20	Site Q	1	-7.2356	72.3472	29/03/2019	11:20
21	Site I a	1	-7.2707	72.4194	30/03/2019	08:55
22	Site J	1	-7.2621	72.4500	30/03/2019	09:15
23	Site H	1	-7.2808	72.4674	30/03/2019	09:40
24	Site F a	1	-7.3228	72.4706	30/03/2019	10:25
25	Plantation Old Dock	0.5	-7.3540	72.4671	31/03/2019	11:15

Sample No	Location	Depth (m)	Latitude	Longitude	Date	Time
26	Beach East Ocean	0.5	-7.3698	72.4829	31/03/2019	11:45
27	Turtle Cove	0.5	-7.4349	72.4349	31/03/2019	12:55
28	Outfall S2f	0.5	-7.2995	72.3890	31/03/2019	16:05
29	Outfall S2g	0.5	-7.2993	72.3890	31/03/2019	16:20
30	Outfall S2h	0.5	-7.2998	72.3901	31/03/2019	16:35
31	Outfall S2i	0.5	-7.3002	72.3905	31/03/2019	16:55
32	Outfall S2j	0.5	-7.2983	72.3889	31/03/2019	17:10
33	Munition Storage	0.5	-7.3793	72.4296	31/03/2019	17:40
34	Thunder Cover Bay	0.5	-7.3132	72.4319	31/03/2019	18:25



Table A1.3. Locations where CTD Profiles were obtained in the upper 30-50 m of the water column. Sensors provide profiles of conductivity (C, i.e. salinity), temperature (T) and depth (D), as well as other parameters (see Section 4).

Station No	Location	Latitude	Longitude	Date	Time
1	Site O	-7.2396	72.3875	28/03/2019	08:30
2	Site M	-7.2546	72.4038	28/03/2019	09:00
3	Site K	-7.2868	72.4036	28/03/2019	09:30
4	Site I	-7.3049	72.4554	28/03/2019	10:00
5	Site F	-7.3518	72.4486	28/03/2019	10:21
6	Site E	-7.3718	72.4412	29/03/2019	10:44
7	Outfall S2a	-7.3056	72.3885	29/03/2019	08:35
8	Outfall S2b	-7.3060	72.3884	29/03/2019	08:50
9	Outfall S2c	-7.3046	72.3880	29/03/2019	09:00
10	Outfall S2d	-7.3037	72.3870	29/03/2019	09:16
11	Outfall S2e	-7.3021	72.3856	29/03/2019	09:40
12	Outfall S1a	-7.2642	72.3577	29/03/2019	10:10
13	Outfall S1b	-7.2634	72.3621	29/03/2019	10:21
14	Outfall S1c	-7.2641	72.3601	29/03/2019	10:34
15	Site P	-7.2636	72.3526	29/03/2019	10:50
16	Site Q	-7.2356	72.3472	29/03/2019	11:20
17	Site M a	-7.2567	72.4020	30/03/2019	08:15
18	Site K a	-7.2632	72.4113	30/03/2019	08:30
19	Site I a	-7.2707	72.4194	30/03/2019	08:55
20	Site J	-7.2621	72.4500	30/03/2019	09:15
21	Site H	-7.2808	72.4674	30/03/2019	09:40
22	Site G	-7.2996	72.3320	30/03/2019	10:03
23	Site F a	-7.3228	72.4706	30/03/2019	10:25

Table A1.4. Locations where sampling was carried out for microbiological pathogens (E. coli).

Sample No	Location	Depth (m)	Latitude	Longitude	Date	Time
1	Plantation R&R	0.5	-7.3472	72.4655	26/03/2019	15:30
2	Moody Brook	0.5	-7.2735	72.3745	26/03/2019	18:33
3	Waste Management	0.5	-7.3486	72.4338	27/03/2019	12:45
4	Leisure Marina A	0.5	-7.2913	72.3905	27/03/2019	17:27
5	Site O	1	-7.2396	72.3875	28/03/2019	08:30
6	Site M	1	-7.2546	72.4038	28/03/2019	09:00
7	Site K	1	-7.2868	72.4036	28/03/2019	09:30
8	Site I	1	-7.3049	72.4554	28/03/2019	10:00
9	Site F	1	-7.3518	72.4486	28/03/2019	10:21
10	Site E	1	-7.3718	72.4412	29/03/2019	10:44
11	Outfall S2a	1	-7.3056	72.3885	29/03/2019	08:35
12	Outfall S2b	1	-7.3060	72.3884	29/03/2019	08:50
13	Outfall S2c	1	-7.3046	72.3880	29/03/2019	09:00
14	Outfall S2d	1	-7.3037	72.3870	29/03/2019	09:16
15	Outfall S2e	1	-7.3021	72.3856	29/03/2019	09:40
16	Outfall S1a	1	-7.2642	72.3577	29/03/2019	10:10
17	Outfall S1b	1	-7.2634	72.3621	29/03/2019	10:21
18	Outfall S1c	1	-7.2641	72.3601	29/03/2019	10:34
19	Site P	1	-7.2636	72.3526	29/03/2019	10:50
20	Site Q	1	-7.2356	72.3472	29/03/2019	11:20
21	Site I a	1	-7.2707	72.4194	30/03/2019	08:55
22	Site J	1	-7.2621	72.4500	30/03/2019	09:15
23	Site H	1	-7.2808	72.4674	30/03/2019	09:40
24	Site F a	1	-7.3228	72.4706	30/03/2019	10:25
25	Plantation Old Dock	0.5	-7.3540	72.4671	31/03/2019	11:15

Sample No	Location	Depth (m)	Latitude	Longitude	Date	Time
26	Beach East Ocean	0.5	-7.3698	72.4829	31/03/2019	11:45
27	Turtle Cove	0.5	-7.4349	72.4349	31/03/2019	12:55
28	Outfall S2f	0.5	-7.2995	72.3890	31/03/2019	16:05
29	Outfall S2g	0.5	-7.2993	72.3890	31/03/2019	16:20
30	Outfall S2h	0.5	-7.2998	72.3901	31/03/2019	16:35
31	Outfall S2i	0.5	-7.3002	72.3905	31/03/2019	16:55
32	Outfall S2j	0.5	-7.2983	72.3889	31/03/2019	17:10
33	Munition Storage	0.5	-7.3793	72.4296	31/03/2019	17:40
34	Thunder Cover Bay	0.5	-7.3132	72.4319	31/03/2019	18:25

Table A1.5. Locations where one-litre water samples were collected for screening for contaminants.

Sample No	Location	Depth (m)	Latitude	Longitude	Date	Time
1	Plantation R&R	0.5	-7.3472	72.4655	26/03/2019	15:30
2	Moody Brook	0.5	-7.2735	72.3745	26/03/2019	18:33
3	Waste Management	0.5	-7.3486	72.4338	27/03/2019	12:45
4	Leisure Marina A	0.5	-7.2913	72.3905	27/03/2019	17:27
5	Site O	1	-7.2396	72.3875	28/03/2019	08:30
6	Site M	1	-7.2546	72.4038	28/03/2019	09:00
7	Site K	1	-7.2868	72.4036	28/03/2019	09:30
8	Site I	1	-7.3049	72.4554	28/03/2019	10:00
9	Site F	1	-7.3518	72.4486	28/03/2019	10:21
10	Site E	1	-7.3718	72.4412	29/03/2019	10:44
11	Outfall S2a	1	-7.3056	72.3885	29/03/2019	08:35
12	Outfall S2e	1	-7.3021	72.3856	29/03/2019	09:40
13	Outfall S1a	1	-7.2642	72.3577	29/03/2019	10:10
14	Site P	1	-7.2636	72.3526	29/03/2019	10:50
15	Site Q	1	-7.2356	72.3472	29/03/2019	11:20
16	Site J	1	-7.2621	72.4500	30/03/2019	09:15
17	Site H	1	-7.2808	72.4674	30/03/2019	09:40
18	Outfall S2f	0.5	-7.2995	72.3890	31/03/2019	16:05
19	Outfall S2g	0.5	-7.2993	72.3890	31/03/2019	16:20

Table A1.6. Locations where samples were collected for toxicity tests.

Sample No	Location	Depth (m)	Latitude	Longitude	Date	Time
1	Plantation R&R	0.5	-7.3472	72.4655	26/03/2019	15:30
2	Moody Brook	0.5	-7.2735	72.3745	26/03/2019	18:33
3	Short Pier	0.5	-7.2598	72.4338	27/03/2019	12:05
4	Waste Management	0.5	-7.3486	72.4338	27/03/2019	12:45
5	Leisure Marina A	0.5	-7.2913	72.3905	27/03/2019	17:27
6	Site O	1	-7.2396	72.3875	28/03/2019	08:30
7	Site M	1	-7.2546	72.4038	28/03/2019	09:00
8	Site K	1	-7.2868	72.4036	28/03/2019	09:30
9	Site I	1	-7.3049	72.4554	28/03/2019	10:00
10	Site F	1	-7.3518	72.4486	28/03/2019	10:21
11	Site E	1	-7.3718	72.4412	29/03/2019	10:44
12	Outfall S2a	1	-7.3056	72.3885	29/03/2019	08:35
13	Outfall S2b	1	-7.3060	72.3884	29/03/2019	08:50
14	Outfall S2c	1	-7.3046	72.3880	29/03/2019	09:00
15	Outfall S2d	1	-7.3037	72.3870	29/03/2019	09:16
16	Outfall S2e	1	-7.3021	72.3856	29/03/2019	09:40
17	Outfall S1a	1	-7.2642	72.3577	29/03/2019	10:10
18	Outfall S1b	1	-7.2634	72.3621	29/03/2019	10:21
19	Outfall S1c	1	-7.2641	72.3601	29/03/2019	10:34
20	Site P	1	-7.2636	72.3526	29/03/2019	10:50
21	Site Q	1	-7.2356	72.3472	29/03/2019	11:20
22	Site I a	1	-7.2707	72.4194	30/03/2019	08:55
23	Site J	1	-7.2621	72.4500	30/03/2019	09:15
24	Site H	1	-7.2808	72.4674	30/03/2019	09:40
25	Site F a	1	-7.3228	72.4706	30/03/2019	10:25

Sample No	Location	Depth (m)	Latitude	Longitude	Date	Time
26	Plantation Old Dock	0.5	-7.3540	72.4671	31/03/2019	11:15
27	Beach East Ocean	0.5	-7.3698	72.4829	31/03/2019	11:45
28	Turtle Cove	0.5	-7.4349	72.4349	31/03/2019	12:55
29	Outfall S2f	0.5	-7.2995	72.3890	31/03/2019	16:05
30	Outfall S2g	0.5	-7.2993	72.3890	31/03/2019	16:20
31	Outfall S2h	0.5	-7.2998	72.3901	31/03/2019	16:35
32	Outfall S2i	0.5	-7.3002	72.3905	31/03/2019	16:55
33	Outfall S2j	0.5	-7.2983	72.3889	31/03/2019	17:10
34	Munition Storage	0.5	-7.3793	72.4296	31/03/2019	17:40
35	Thunder Cover Bay	0.5	-7.3132	72.4319	31/03/2019	18:25
36	Waste Management	0.5	-7.3482	72.4341	01/04/2019	12:15
37	Waste Management	0.5	-7.3484	72.4340	01/04/2019	12:20
38	Waste Management	0.5	-7.3486	72.4339	01/04/2019	12:25
39	Waste Management	0.5	-7.3487	72.4338	01/04/2019	12:30
40	Waste Management	0.5	-7.3488	72.4338	01/04/2019	12:35
41	Landfill Leachate	0.5	-7.3558	72.4326	01/04/2019	12:50

